

CLAIMS

1. A method for modifying a digital image (100) composed of pixels having pixel values (102); the said digital image being decomposed into zones (103); each of the said pixels being associated with at least one adjacent zone (105); at least one zone value (104) being allocated to each of the said zones Zi (103); at least one parameter value Vpij (203) being allocated to each of the said zones Zi (103); a set of pairs (Zi; Vpij), composed of a zone Zi (103) and of a parameter value Vpij (203) associated with the said zone (103), constituting a parameter image (201);

the method said including:

- (a) the stage of determining, for each zone (103), determined parameter values Vpir (305), in particular as a function of the zone values (104) of the said digital image (100); the said parameter image (201) formed in this way being referred to hereinafter as the determined parameter image (505);

the said zone values (104) varying between at least one of the said zones (103) and a contiguous zone (403), the said variation being referred to hereinafter as the variation (401) of the digital image;

the said determined parameter values (305) varying between the said zone (103) and at least one contiguous zone (403), the said variation being referred to hereinafter as the variation of the determined parameter image (402);

the said method additionally including the following stages:

- (b) the stage of regularizing the determined parameter image (505) as a function of the said variation (401) of the digital image, by reducing the said variations of the determined parameter image (505) in order to produce a parameter image, referred to hereinafter as the regularized parameter image (507), having a smaller variation level than that of the said variations (401) of the digital image;

- (c) the stage of modifying the pixel values (102) of a determined pixel (101) of the said digital image (100) as a function of the parameter values (203) of the said regularized parameter image (507), relative to the zones adjacent to the said determined pixel;

so that the digital image is modified differentially for each of the said pixels and quasi-regularly for the contiguous zones.

2. A method according to claim 1; the said method being such that each zone (103) is composed of one pixel (101).

3. A method according to any one of claims 1 or 2; the said method being such that each zone (103) is composed of a group of contiguous pixels (101).

4. A method according to any one of claims 1 to 3; the said determined parameter values (305) being the said zone values (104).

5. A method according to any one of claims 1 to 4; the said zone value (104) being the maximum value of the pixel values (102) associated with the said zone (103) and/or the minimum value of the pixel values (102) associated with the said zone (103) and/or a value calculated from the pixel values (102) associated with the said zone (103).

6. A method according to any one of claims 1 to 5; a single determined parameter value (305) having been allocated to each zone (103);

the said parameter images (201) whose variation level is smaller than that of the said variations of the digital image being referred to hereinafter as controlled variation images; the said method, in order to reduce the said variations of the determined parameter image and to produce a regularized parameter image (507) having a variation level smaller than that of the said variations of the digital image (100), additionally comprising:

- the stage of selecting, from among the controlled variation images, a parameter image that is close (within the meaning of the present invention) to the determined parameter image (505);

so that there is obtained a parameter image constituting the regularized parameter image.

7. A method according to any one of claims 1 to 5; a single determined parameter value (305) having been allocated to each zone (103);

the said parameter images whose variation level is smaller than that of the said variations of the digital image being referred to hereinafter as controlled variation images; the said method, in order to reduce the said variations of the determined parameter image (505) and to produce a regularized parameter image (507) having a variation level smaller than that of the said variations of the digital image, additionally including:

- the stage of selecting, from among the controlled variation images, a parameter image (c) ( $Z_i; V_{pi}(c)$ ) that satisfies the following conditions:

- \* the determined parameter value ( $V_{pij}$ ) of the determined parameter image of any zone ( $Z_i$ ) whatsoever is smaller than or equal to the said parameter value ( $V_{pi}(c)$ ) of the selected parameter image (c), at least for several zones,

- \* the parameter value ( $V_{pi}(c)$ ) of the selected parameter image (c) of a zone ( $Z_i$ ) is smaller than or equal to the parameter values ( $V_{pi}(q)$ ) for most of the controlled variation images (q) ( $Z_i; V_{pi}(q)$ ), at least for several zones;

so that there is obtained a parameter image constituting the regularized parameter image.

8. A method according to any one of claims 1 to 5; a single determined parameter value (305) having been allocated to each zone (103);

the said parameter images whose variation level is smaller than that of the said variations of the digital image being referred to hereinafter as controlled variation images; the said method, in order to reduce the said variations of the determined parameter image (505) and to produce a regularized parameter image (507) having a variation level smaller than that of the said variations of the digital image, additionally including:

- the stage of selecting, from among the said controlled variation images, a parameter image (c) ( $Z_i; V_{pi}(c)$ ) that satisfies the following conditions:

- \* the determined parameter value ( $V_{pij}$ ) of the determined parameter image of any zone ( $Z_i$ ) whatsoever is larger than or equal to the said parameter value ( $V_{pi}(c)$ ) of the selected parameter image (c), at least for several zones,

- \* the parameter value ( $V_{pi}(c)$ ) of the selected parameter image (c) of a zone ( $Z_i$ ) is larger than or equal to the parameter values ( $V_{pi}(q)$ ) for most of the controlled variation images (q) ( $Z_i; V_{pi}(q)$ ), at least for several zones;

so that there is obtained a parameter image constituting the regularized parameter image.

9. A method according to any one of claims 1 to 5; the said method, in order to regularize the determined parameter image as a function of the said variation of the digital image, employing the algorithm that includes the following stages:

the stage of determining, for a defined zone  $Z_i$ , the parameter value  $V_{pi}(n+1)$  of the said pair ( $Z_i; V_{pi}(n+1)$ ) of the  $n+1$ -th parameter image by combining:

- \* the parameter values  $V_{pj}(n)$  and/or  $V_{pj}(n+1)$  of the pairs of the  $n$ -th image and/or of the  $n+1$ -th image whose zones  $Z_j$  are situated in the vicinity of the said zone  $Z_i$  with

\* corrective values that are functions of the variations of the digital image between the said zone  $Z_i$  and the said zones  $Z_j$ ,

- the stage of iterating the preceding stage step by step;

the said algorithm being initialized by applying it at first to the pairs of the said determined parameter image.

10. A method according to any one of claims 1 to 9; the said method, in order to modify the pixel values (102) of a determined pixel (101) of the digital image (100), additionally including the following stages:

- the stage of interpolating a parameter value relative to the said determined pixel (603) from parameter values of the said regularized parameter image (507), relative to the zones adjacent to the said determined pixel,

- the stage of modifying the value of the said determined pixel by employing the parameter value (603) interpolated in this way.

11. A method according to any one of claims 1 to 9; a single determined parameter value (305) having been allocated to each zone (103), the said method, in order to modify the pixel values (102) of a determined pixel (101) of the said digital image (100), additionally including the following stages:

- the stage of interpolating a parameter value relative to the said determined pixel (603) from parameter values of the said regularized parameter image (507), relative to the zones adjacent to the said determined pixel,

- the stage of calculating a coefficient (1104) by applying a predetermined function, especially the gamma, to the parameter value (603) interpolated in this way,

- the stage of multiplying the pixel values (102) of the said determined pixel by the said coefficient (1104).

12. A method according to any one of claims 1 to 9; two determined parameter values having been allocated to each zone, referred to hereinafter as the first parameter value and the second parameter value; the said method, in order to modify the pixel

values (102) of a determined pixel (101) of the said digital image (100), additionally including the following stages:

- the stage of interpolating a first parameter value relative to the said determined pixel from the said first parameter values of the said regularized parameter image (507), relative to the zones adjacent to the said determined pixel,

- the stage of interpolating a second parameter value relative to the said determined pixel from the said second parameter values of the said regularized parameter image (507), relative to the zones adjacent to the said determined pixel,

- the stage of choosing an affine transformation (1204) as a function of the said first parameter value and the said second parameter value interpolated in this way,

- the stage of applying the said affine transformation (1204) to each of the pixel values.

13. A method according to any one of claims 1 to 12; the said method, in order to modify the pixel values of a determined pixel of the said digital image, additionally including the following stages:

- the stage of calculating a coefficient as a function of the parameter values of the said regularized parameter image and of the pixel values,

- the stage of calculating each pixel value of the said determined pixel as a function of the said coefficient and of the said pixel values of the said determined pixel.

14. A method according to any one of claims 1 to 13; the said method, in order to modify the pixel values of a determined pixel of the said digital image, additionally including the following stages:

- the stage of calculating a coefficient as a function of the parameter values of the said regularized parameter image and of the pixel values,

- the stage of multiplying each pixel value of the said determined pixel by the said coefficient.

15. A method according to any one of claims 1 to 14; the said method being intended to augment the luminosity of the dark parts (1002) of the said digital image; the said method being additionally more particularly to preserve the luminosity of those parts of the said digital image that are dark and of small extent;

the said method additionally including the stage of calculating the determined parameter values of the zones of the said parts that are dark and of small extent, from the determined parameter values of the adjacent zones, so that the difference between the determined parameter values for the zones in question is small.

#### System

16. A system for modifying a digital image (100) composed of pixels (101) having pixel values (102); the said digital image (100) being decomposed into zones  $Z_i$  (103); each of the said pixels (101) being associated with at least one adjacent zone; at least one zone value (104) being allocated to each of the said zones  $Z_i$  (103); at least one parameter value  $V_{pij}$  (203) being allocated to each of the said zones  $Z_i$  (103); a set of pairs  $(Z_i; V_{pij})$ , composed of a zone  $Z_i$  (103) and of a parameter value  $V_{pij}$  (203) associated with the said zone  $Z_i$  (103), constituting a parameter image (201);

the said system including:

- (a) a first calculating means (504) making it possible to determine, for each zone (103), determined parameter values  $V_{pir}$  (305), in particular as a function of the zone values (104) of the said digital image (100); the said parameter image formed in this

way being referred to hereinafter as the determined parameter image (505);

the said zone values (104) varying between at least one of the said zones and a contiguous zone, the said variation being referred to hereinafter as the variation (401) of the digital image;

the said determined parameter values (305) varying between the said zone and at least one contiguous zone, the said variation being referred to hereinafter as the variation of the determined parameter image;

the said system additionally including 1:

- (b) a second calculation means (506) making it possible to regularize the determined parameter image (505) as a function of the said variation (401) of the digital image, by reducing the said variations of the determined parameter image in order to produce a parameter image referred to hereinafter as the regularized parameter image (507) having a smaller variation level than that of the said variations (401) of the digital image;

- (c) a third calculating means (508) making it possible to modify the pixel values (102) of a determined pixel (101) of the said digital image (100) as a function of the parameter values of the said regularized parameter image (507), relative to the zones adjacent to the said determined pixel;

so that the said digital image is modified differentially for each of the said pixels and quasi-regularly for the contiguous zones.

17. A system according to claim 16; the said system being such that each zone (103) is composed of one pixel (101).

18. A system according to any one of claims 16 or 17; the said system being such that each zone (103) is composed of a group of contiguous pixels (101).

19. A system according to any one of claims 16 to 18; the said determined parameter values (305) being the said zone values (104).

20. A system according to any one of claims 16 to 19; the said zone value (104) being the maximum value of the pixel values (102) associated with the said zone and/or the minimum value of the pixel values (102) associated with the said zone (103) and/or a value calculated from the pixel values (102) associated with the said zone.

21. A system according to any one of claims 16 to 20; a single determined parameter value (305) having been allocated to each zone (103);

the said parameter images whose variation level is smaller than that of the said variations (401) of the digital image being referred to hereinafter as controlled variation images; the said system, in order to reduce the said variations of the determined parameter image (505) and to produce a regularized parameter image (507) having a variation level smaller than that of the said variations of the digital image, additionally comprising:

- first selection means (703) for selecting, from among the said controlled variation images, a parameter image close (within the meaning of the present invention) to the determined parameter image (505);

so that there is obtained a parameter image constituting the regularized parameter image.

22. A system according to any one of claims 16 to 20; a single determined parameter value (305) having been allocated to each zone (103);

the said parameter images whose variation level is smaller than that of the said variations of the digital image being referred to hereinafter as controlled variation images; the said system, in order to reduce the said variations of the determined parameter image (505) and to produce a regularized parameter image (507) having a variation level smaller than that of the said variations of the digital image, additionally including:

- second selecting means (703) for selecting, from among the said controlled variation images, a parameter image (c) ( $Z_i; V_{pi}(c)$ ) that satisfies the following conditions:

\* the determined parameter value ( $V_{pij}$ ) of the determined parameter image of any zone ( $Z_i$ ) whatsoever is smaller than or equal to the said parameter value ( $V_{pi}(c)$ ) of the selected parameter image (c), at least for several zones,

\* the parameter value ( $V_{pi}(c)$ ) of the selected parameter image (c) of a zone ( $Z_i$ ) is smaller than or equal to the parameter values ( $V_{pi}(q)$ ) for most of the controlled variation images (q) ( $Z_i; V_{pi}(q)$ ), at least for several zones;

so that there is obtained a parameter image constituting the regularized parameter image.

23. A system according to any one of claims 16 to 20; a single determined parameter value (203) having been allocated to each zone (103);

the said parameter images whose variation level is smaller than that of the said variations of the digital image being referred to hereinafter as controlled variation images; the said system, in order to reduce the said variations of the determined parameter image (505) and to produce a regularized parameter image (507) having a variation level smaller than that of the said variations of the digital image, additionally including:

- third selecting means (703) for selecting, from among the said controlled variation images, a parameter image (c) ( $Z_i; V_{pi}(c)$ ) that satisfies the following conditions:

\* the determined parameter value ( $V_{pij}$ ) of the determined parameter image of any zone ( $Z_i$ ) whatsoever is larger than or equal to the said parameter value ( $V_{pi}(c)$ ) of the selected parameter image (c), at least for several zones,

\* the parameter value ( $V_{pi}(c)$ ) of the selected parameter image

(c) of a zone ( $Z_i$ ) is larger than or equal to the parameter values ( $V_{pi}(q)$ ) for most of the controlled variation images ( $q$ ) ( $Z_i; V_{pi}(q)$ ), at least for several zones;

so that there is obtained a parameter image constituting the regularized parameter image.

24. A system according to any one of claims 16 to 20; the said system, in order to regularize the determined parameter image as a function of the said variation of the digital image, employing an algorithm that includes the following stages of calculation:

the stage of determining, for a defined zone  $Z_i$ , the parameter value  $V_{pi}(n+1)$  of the said pair ( $Z_i; V_{pi}(n+1)$ ) of the  $n+1$ -th parameter image by combining:

- \* the parameter values  $V_{pj}(n)$  and/or  $V_{pj}(n+1)$  of the pairs of the  $n$ -th image and/or of the  $n+1$ -th image whose zones  $Z_j$  are situated in the vicinity of the said zone  $Z_i$  with

- \* corrective values that are functions of the variations of the digital image between the said zone  $Z_i$  and the said zones  $Z_j$ ,

- the stage of iterating the preceding stage step by step;

the said algorithm being initialized by applying it at first to the pairs of the determined parameter image.

25. A system according to any one of claims 16 to 24; the said third calculating means (508), in order to modify the pixel values of a determined pixel of the said digital image, executing the following operations:

- the operation (602) of interpolating a parameter value relative to the said determined pixel from parameter values of the said regularized parameter image, relative to the zones adjacent to the said determined pixel,

- the operation (604) of modifying the value of the said determined pixel by employing the parameter value interpolated in this way.

26. A system according to any one of claims 16 to 24; a single determined parameter value having been allocated to each zone; the said third calculating means (508), in order to modify the pixel values of a determined pixel of the said digital image, executing the following operations:

- the operation (1100) of interpolating a parameter value relative to the said determined pixel from parameter values of the said regularized parameter image, relative to the zones adjacent to the said determined pixel,

- the operation (1101) of calculating a coefficient by applying a predetermined function, especially the gamma, to the parameter value interpolated in this way,

- the operation (1102) of multiplying the pixel values of the said determined pixel by the said coefficient.

27. A system according to any one of claims 16 to 24; two determined parameter values having been allocated to each zone, referred to hereinafter as the first parameter value and the second parameter value; the said third calculating means, in order to modify the pixel values of a determined pixel of the said digital image, executing the following operations:

- the operation comprising interpolating a first parameter value relative to the said determined pixel from the said first parameter values of the said regularized parameter image, relative to the zones adjacent to the said determined pixel,

- the operation comprising interpolating a second parameter value relative to the said determined pixel from the said second parameter values of the said regularized parameter image, relative to the zones adjacent to the said determined pixel,

- the operation consisting in choosing an affine transformation as a function of the said first parameter value and the said second parameter value interpolated in this way,

- the operation consisting in applying the said affine transformation to each of the pixel values.

28. A system according to any one of claims 16 to 27; the said third calculating means (508), in order to modify the pixel values of a determined pixel of the said digital image, executing the following operations:

- the operation consisting in calculating a coefficient as a function of the parameter values of the said regularized parameter image and of the pixel values,

- the operation consisting in calculating each pixel value of the said determined pixel as a function of the said coefficient and of the said pixel values of the said determined pixel.

29. A system according to any one of claims 16 to 28; the said third calculating means (508), in order to modify the pixel values of a determined pixel of the said digital image, executing the following operations:

- the operation consisting in calculating a coefficient as a function of the parameter values of the said regularized parameter image and of the pixel values,

- the operation consisting in multiplying each pixel value of the said determined pixel by the said coefficient.

30. A system according to any one of claims 16 to 29; the said system being intended to augment the luminosity of the dark parts (1002) of the said digital image (100); the said system being additionally more particularly to preserve the luminosity of those parts of the said digital image (100) that are dark and of small extent;

the said system additionally including a fourth calculating means (902) for calculating the determined parameter values of the zones of the said parts that are dark and of small extent, from the determined parameter values of the adjacent zones, so that the

difference between the determined parameter values for the zones in question is small.